Replacing the -4.77% growth rate for the price of capital with -1.5% and combining this with Norsworthy's input cost shares and price data for labor and materials raises the growth rate of LEC input prices from Norsworthy's reported 0.46% to 1.50%. Comparing this growth rate with the now symmetrically defined U.S. input price growth rate reported by Norsworthy (3.00%) yields an input price differential equal to 1.5% (3.00%-1.50%), not the 2.54% Norsworthy reports and well below the 2.2% differential produced by Bush-Uretsky. The extent of bias embedded in the Norsworthy analysis is significant.

If Norsworthy and ETI intend to submit input price differentials based on hedonic techniques, it is their burden to compare U.S. and LEC price aggregates using a common methodology. There is no ambiguity in either the Norsworthy and ETI texts. Neither adjusts the U.S. data for quality change. Moreover, ETI recognizes explicitly that GDP-PI is not quality adjusted.

Clearly, the FCC must not accept the AT&T and ETI analyses. Moreover, the Commission must not accept the inference regarding the 'X' factor drawn explicitly in the ETI report. ETI concludes in numerous places that if one fails to incorporate hedonic quality adjustments in LEC input prices, the resulting 'X' factor will be downward biased. Two examples should suffice:

> Sensitivity analysis of Christensen's results indicates that incorporation of hedonic price adjustments would result in a significantly higher 'X' factor.[10]

> Failure to make hedonic price adjustments will necessarily overstate input price growth and result in an 'X' factor that is misspecified and biased downward.[11]

---

[10] ETI Statement, p. 27.

[11] Ibid., p. 36.

This conclusion simply is incorrect, as a matter of the mathematics underlying productivity accounting. Any hedonic adjustment made to an input's price (whether upward or downward) tautologically infers an exactly offsetting adjustment to the corresponding input quantity. As a result, any quality adjustment that reduces an input's price growth by X% and therefore widens the measured input price differential necessarily produces an exactly offsetting increase in the input's quantity growth, thereby narrowing any measured productivity differential and leaving the resulting 'X' factor unaffected. ETI concedes this point in its prepared statement:

> Whether a TFP study, such as the one performed by Christensen, measures input quantities directly or computes them indirectly by deflating input expenditures by input prices does not alter the fundamental accounting identity upon which a TFP study is based. This fundamental accounting identity holds that expenditures (on inputs or outputs) equal prices times quantities. One can use data on any two of the three variables, expenditures, prices, or quantities, to derive the third unknown variable. Indeed, Christensen's TFP study makes repeated use of this fundamental accounting identify....The three variables must be internally consistent. Thus, for a given series of input expenditure data, if one assumes a higher rate of input price growth, then by virtue of the fundamental accounting identity, there will be a correspondingly lower rate of input quantity growth--regardless of whether input quantity growth in the study was initially measured on a direct basis or computed indirectly from data on input price growth and input expenditures.[12]

Put simply, ETI's conclusions must be judged by its own standard. Hedonic adjustments applied to input prices and symmetrically and correctly applied to input quantities cannot, as a matter of mathematics, affect the

---

[12] Ibid., pp. 44-45. The context within which the ETI statement is made is part of a criticism of the Christensen TFP model since, because its capital input quantities are measured directly, increases in input price inflation do not necessarily translate directly in the Christensen model into lower rates of input quantity growth. It is important to note that the "accounting identity" ETI references does not refute Christensen's direct and therefore independent measurement of capital input and its service price. However, once those input and price measures have been established, the accounting identity does require that hedonic adjustments made to capital's input price must symmetrically be made to its input quantity. In short, ETI's statement applies to hedonic adjustments, not to the direct measurement of capital input.

resulting 'X' factor. In fact, ETI persuasively illustrates the symmetric but offsetting hedonic treatment of prices and quantities through the following tire example attributed to the Director of the Congressional Budget Office:

> ...if the price of a tire increases but the quality of the tire is improved, then the change in the cost of living cannot be measured as simply a change in price. If the price doubles but the tire lasts twice as long,...then the quality-adjusted price change may in fact be zero or even negative.[13]

In the CBO example, a new improved tire effectively equals two old tires because "the (new) tire lasts twice as long." Consequently, to measure the number of new tires in "constant-quality" units comparable to old tires, the physical number of new tires must be doubled. Symmetrically, the measured increase in tire prices must be cut in half. The important conclusion for purposes of the present discussion is that quality adjustments to price and quantity are opposite and therefore offsetting.

Norsworthy, in his above referenced discussion of the application of hedonics, weighs in on the same point:

> This hedonic adjustment was extended to the 1991-1994 period, and results in an average annual downward adjustment (in the average annual growth of capital input price for the LECs) of 3.27 percent. This corresponds to an annual increase in the effective capital input of the same magnitude for the period 1985-1994.[14]

By inference, productivity growth contracts by the same amount (because of the increase in "effective capital input") by which the input price differential grows (because of the decrease in the effective price of capital), thereby leaving 'X' unaffected.

---

[13] ETI Statement, p. 37. Original found in "Statement of June E. O'Neill, Director, Congressional Budget Office on the Consumer Price Index before the Committee on Finance United States Senate," Congressional Budget Office Testimony, March 13, 1995 at p. 8.

[14] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 20.

Not only must ETI's policy conclusion be rejected, but ETI needs to explain its empirical results. Toward the end of its report, ETI attempts to simulate through its 'X' factor model the effect of incorporating hedonic adjustments on its overall 'X' factor. The simple mathematics underlying TFP accounting, ETI's reference to the "fundamental accounting identity," and even Norsworthy's text assure us that the only theoretically correct answer is "zero." ETI, however, finds that its simulated hedonic adjustment leads to a 0.4% increase in its 'X' factor:

> In the previous section of this report, the importance of hedonic price changes for telecommunications inputs was firmly established. However, the impact on the 'X' factor from including hedonic adjustments is an empirical matter that cannot be determined *a priori*....To demonstrate the degree of sensitivity of the 'X' factor result to the inclusion of hedonic adjustments, we have estimated the effect of a modest 10% annual downward adjustment in the asset price deflators most closely associated with computers...Incorporation of this highly conservative adjustment for quality effects, as summarized in Table 5, increases the corrected interstate 'X' factor from 9.9% to 10.3%. Similarly, the corrected total company 'X' factor further adjusted for hedonic effects increases from 7.1% to 7.5%.[15]

Given the large number of interrelated steps involved in the calculation of capital input and its service price, one might expect an 'X' difference that is not numerically identical to zero, but the burden is on ETI not only to explain its 0.4% differential but also to justify its theoretical foundation and consequent use as a basis for raising its recommended 'X' factor. ETI's conclusions are unsound *a priori* .

Two final notes on hedonic adjustments are in order. First, proper applications of hedonic price adjustments require considerable disaggregated data and cannot avoid econometric modeling. The required data are unlikely to be publicly available. The application of econometrics is likely to raise

---

15 ETI Statement, p. 57.

contentious modeling issues. Second, the simplified TFP model submitted by USTA/Christensen relies on Bureau of Economic Analysis price indexes. The few hedonic price adjustments BEA has introduced into its price series are reflected in both the economy-wide and USTA/Christensen price series.

The FCC should not consider the AT&T and ETI recommendation for an asymmetric hedonic adjustment to LEC input prices. Doing so would clearly be a boon for economic consultants engaged in econometric research, but it is both unnecessary given the "fundamental accounting identity" and ill-advised given that economy-wide price indexes currently are not symmetrically quality adjusted.

B. Issue 1i: Statistical Testing for an Input Price Differential

There has been much discussion of the USTA/Christensen and Bush-Uretsky tests regarding the significance of an input price differential. There is little need to cover old ground. The objective of this section is only to address two new points raised by Norsworthy in his prepared statement.

(i) *Norsworthy's claim that U.S. and LEC input prices must be identical at each point in time to support USTA/Christensen.*

Norsworthy states:

> The correct way to assess whether the two series (U.S. and LEC input prices) are the same is to compare them directly. When USTA proposes using the movements in the US input price index to represent or be equivalent to movements in the LEC input price index, it is proposing that the series are the same. USTA's position is not the same as saying that there is no significant difference between the movements of the series.[16]

---

16 Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 9.

Norsworthy is simply wrong. The input price differential question before the Commission (and the one tested by Christensen in his report for USTA) is whether or not U.S. and LEC prices have exhibited (and are expected to exhibit) significantly different growth rates--not whether or not U.S. and LEC input prices have been identical at each point in time. The appropriate statistical test of the relevant underlying hypothesis does not require that the underlying U.S. and LEC prices be identical or even that year-to-year changes in U.S. and LEC input prices be identical. Norsworthy's chi-squared test is testing far too strong a condition--and therefore one that not surprisingly is rejected. What is appropriate to test is whether or not the differences observed over time between LEC and U.S. input price growth rates are systematic differences that are found to be statistically different from zero.

Consider an analogy. Two cars leave the same origin and arrive at the same destination at exactly the same times. Over the 10-hour trip each car averages 60 mph but within each hour of the trip (the annual observation in Norsworthy's argument) each car has a different rate of speed ranging between 50 and 70 mph. Rates of speed in each hour are "not the same" and yet (a) there is no systematic difference between the miles-per-hour rates, (b) there is no statistically significant difference, and (c) their overall miles-per-hour rates are identical at 60 mph. The appropriate miles-per-hour differential should be zero even though a hypothesis testing equality of miles-per-hour rates at each point in time would be rejected. Norsworthy's chi-squared test is misspecified; its results do not advance the debate.

(ii) *Norsworthy's Use of Statistical Significance.*

Norsworthy appears ready to embrace the Bush/Uretsky finding that differences in movements in telephone input price indexes before and after divestiture are statistically significant.

> They (Bush and Uretsky) apply econometric methods to compare longer term movements in telephone and economy-wide input prices. They find that there are significant differences between movements of telephone input prices before and after divestiture, and that post-divestiture prices should be the basis of price cap regulation of the LECs.[17]

However, Norsworthy is unwilling to accept USTA/Christensen results that suggest that the Bush/Uretsky 2.2% estimate is not statistically different from zero. In so doing, Norsworthy is inventing a curious use of statistics. His position can be stated as follows: When a parameter is statistically different from zero (e.g. the difference in the pre and post-divestiture Bush/Uretsky differentials) adopt it; when a parameter is not statistically different from zero (the Christensen analysis of the Bush/Uretsky 2.2%), use it anyway. Norsworthy effectively discards the information contained in standard errors, T-statistics, and confidence intervals. This is a most unusual application of applied statistics.

C. Issue 1j: Interstate Services v. Company-Level Analysis

Distinguishing separate TFP growth rates for interstate access services and rest-of-company services cannot be accomplished in any economically meaningful way because it requires separate, economically defensible measures of inputs and outputs for each subset of LEC outputs. Data supporting the computation of distinct growth rates for interstate and rest-of-

---

[17] Ibid., p. 7.

company output certainly do exist. The well-understood difficulty, however, lies with attempting to distinguish inputs.

This follows from the fact that LEC interstate and intrastate services are produced with common inputs. In economic theory, the production of multiple products with common and joint inputs is not separable into distinct parts. In short, one cannot examine the cost (productivity) conditions of each output in isolation because the multiple outputs are not produced in isolation. It is important to note that the problem is not that economic theory offers no guidance in how to allocate common costs. Economic theory is clear. Production under conditions of common costs prevents any economically meaningful allocation of costs to distinct sets of products. Allocating costs to distinct outputs contradicts the very process of joint production that is observed in the industry.

Norsworthy and ETI proceed in spite of the unambiguous proscription of economic theory and, in fact, each recommends the same procedure. They suggest adopting the assumption that identical input growth rates be assigned to each class of output service.[18]

ETI bases its position on the apparent relative constancy of interstate cost shares in total company expenses in the 1991-94 period.

> As shown in Table 2, the trend in composite interstate cost assignment has been very stable (in the vicinity of 24%) over the past several years of price cap regulation, despite the phase-out of the Subscriber Plant Factor during this period. As such, input growth in the interstate jurisdiction can be approximated by total company input growth.[19]

---

18 Ibid., p. 27 and ETI Statement, p. 49-50.

19 ETI Statement, p. 50.

This result, however, reflects an industry convention rather than any true economic reality, as explained by ETI on the page immediately preceding the above quote:

> Most LEC plant and associated expenses are assigned to the interstate and state jurisdictions on the basis of a fixed 25/75 ratio that was established by the Federal/State Joint Board in CC Docket 87-339.[20]

ETI reveals its own assessment of the economic meaningfulness of cost allocations under the Part 36 rule:

> The manner by which investment costs and ongoing operating expenses as allocated between the interstate and state jurisdictions is dictated by Part 36 of the Commission's rules and bears little direct relationship to the manner in which costs are actually incurred. Consequently, it would be highly coincidental--and highly unlikely--for the pattern of cost growth in each of the two jurisdictions to track the year-to-year incremental change in economic costs engendered by the ongoing provision of services.[21]

Though ETI defers to a Part 36 accounting convention, ETI offers absolutely no economic basis for its assumption that interstate and intrastate inputs growth at identical rates.

It is important to emphasize that this is no inconsequential matter. ETI concludes that its distinction of interstate and rest-of-company activity leads to nearly a three percentage point increase in its 'X' factor.

> Perhaps the most significant result of our analysis is the substantially higher TFP associated with services subject to interstate (FCC) jurisdiction in contrast to the Total Company TFP that was calculated in the Christensen/USTA study. Making no changes to the Christensen study or data other than to adjust for interstate-specific output growth, the 'X' factor result... increases 2.8% from 5.1 %...to 7.9%.[22]

---

[20] Ibid., p. 49.
[21] Ibid., p. 47.
[22] Ibid., p. 55.

The ETI increase in 'X' of 2.8 percentage points, however, has no economic basis.

Norsworthy's justification for the same assumption is somewhat more creative but no less flawed. Norsworthy implicitly recognizes that cost allocations to interstate and rest-of-company categories are difficult and therefore he does not attempt to justify it directly. Instead, he argues that assuming equal input growth rates for the two service classes is a "conservative" strategy. By "conservative" he means that, if anything, his assumption of equal input growth rates leads to a pro-LEC result in that, if one truly knew how to allocate costs, input growth for interstate service would be found to be less than the input growth for rest-of-company services. It therefore is his opinion that his equal input growth rate assumption understates interstate TFP growth and therefore leads to a lower 'X' than would result if one knew how to correctly allocate costs.

> Interstate access services rely more on fixed inputs, e.g. switches and transmission equipment, and less on labor and materials inputs, than do local services. Consequently, there should be greater economies of scale in the LECs' provision of interstate access than in their other telephone services. **Therefore, if we assume that inputs grow at the same rates for interstate access and other regulated telephone services provided by the LECs, the resulting implied allocation of costs is conservative.**[23] (Emphasis in original.)

The key to evaluating Norsworthy's position is understanding the basis for his conclusion that his analysis is "conservative." That is accomplished by parsing his argument as presented in the above paragraph. It turns out that the basis he provides leads to exactly the opposite conclusion: Assuming one could meaningfully allocate inputs, Norsworthy's analysis and his own data indicate that interstate inputs would be expected to grow faster than intrastate inputs.

---

[23] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 27.

For purposes of argument only, the following discussion accepts the different input mix requirements of interstate and local services claimed in the first sentence of the above quote. Sentence two then posits that interstate services exhibit greater scale economies than do local services. Though this conclusion does not necessarily follow from the different input mixes in sentence one (after all it is the increasing computerization of the American economy that has undercut traditional scale economies, reduced barriers to entry, and led to competition in telecommunications), the discussion below grants this as well for sake of argument.

Sentence three now poses the logical fallacy. Read carefully and literally, it states that "if we assume that inputs grow at the same rates for interstate access and other regulated telephone services provided by the LECs, the resulting implied allocation of costs is conservative." First of all, it is the assumed premise in the sentence that requires justification, not the resulting inference for allocated costs. Second, it is the assumed equal rates of growth for inputs and not some underlying allocation of costs that are relevant for the purposes of evaluating TFP growth. TFP growth is defined as the difference between the growth in output and the growth in input. As Norsworthy himself admits in the sentence immediately following the above text: "It is important to note, however, that no specific allocation of costs is required by the assumption that inputs grow at the same rates for all classes of service."[24] Not only is none required, none is even inferred! Read quickly, the incorrect inference that might be drawn from the Norsworthy text is that his assumption of equal input growth rates is conservative. In fact, absolutely no basis (economic or otherwise) is given for this assumption.

---

[24] Ibid.

Interestingly, even with the assumption of equal input growth rates, Norsworthy's statement is patently false--as a simple matter of economic logic. The last sentence in the above citation would be true if and only if it was the case that interstate and local outputs were growing at the same rate. If both outputs were growing at the same rate, then under Norsworthy's stated assumption of greater scale economies for interstate service, one would expect that the true input growth rate for interstate service (if it were knowable) would be lower than that for local service, thereby making Norsworthy's assumption of equal growth rates "conservative." But Norsworthy himself makes much of the point that interstate service volume has been growing faster (6.83%) than other output services (4.22%).[25] In so doing, Norsworthy contradicts the very basis both for his assumption that interstate and local inputs grow at equal rates and for his inference that the equal growth rate assumption is conservative.

In addition to this clear misapplication of economic theory, consider the stringent condition Norsworthy imposes on himself by his premise in the first sentence which asserts that interstate and local services have different combinations of labor, capital, and material inputs. By adopting the premise that input mixes differ but that overall aggregate input growth rates for interstate and local service are equal, Norsworthy must additionally maintain that all three inputs grow at exactly the same rate. If they grow at different rates and have different cost shares as he maintains, then it is most unlikely that overall interstate and local service input growth rates are equal.

Norsworthy presents no evidence in his filed attachment to the AT&T statement that labor, capital, and material inputs have identical growth rates. In fact, though Norsworthy provides many tables in his attachment, he does

---

[25] Ibid., p. 26.

not report the input growth rates he uses in his analysis. However, the machine-readable data files underlying his study display the average annual growth rates for labor, capital, and material inputs over the 1985-94 period which, according to Norsworthy, are -3.39%, 3.95%, and 4.05%, respectively. They clearly are not equal and, therefore, given different interstate and local service input requirements, refute Norsworthy's assumption of equal overall input growth rates for interstate and local service.

In fact, Norsworthy's own data can be used to show that his conclusion is far from "conservative." First, Norsworthy's premise that interstate services are more capital intensive than non-interstate services necessarily suggests that the implied interstate cost share of capital input must (under his premise) be greater than the cost share of capital input in non-interstate service. (It follows that the cost shares of labor and materials must collectively be lower.) Second, Norsworthy's data reveal that capital input has grown at an annual rate of 3.95% which is greater than the cost-share weighted average of his reported labor and material growth rates (0.93%).[26] The necessary inference is that, even if one could disaggregate inputs into distinct interstate and non-interstate categories, the cost-share weighted average growth rate of interstate inputs, under Norsworthy's assumptions, must be greater than the corresponding average for non-interstate inputs. After all, interstate services, according to Norsworthy, have a larger weight on the fastest growing input (capital)--precisely the opposite of what Norsworthy must maintain to be "conservative." The difficulty remains, however, that this qualitative conclusion simply cannot and, according to economic theory,

---

[26] See data diskette accompanying Norsworthy attachment to AT&T filing under CC Docket 94-1.

should not be quantified. There is no economically meaningful way to allocate inputs to interstate and non-interstate services.

It follows that Norsworthy's third sentence is simply reversed. His argument is not "conservative" in the sense he intends the reader to infer. The conditions necessary to support Norsworthy's assumption of equal input growth rates are simply contradicted by his own data. The only possible inference of his data is that if one adopts the totally unfounded assumption of equal input growth rates for interstate and non-interstate services one would produce a downward biased measure of interstate input growth and therefore an upward biased measure of interstate TFP growth.

By how much? It is unknowable in any economically meaningful and defensible way. There is no way to separately analyze interstate and non-interstate TFP growth rates short of allocating inputs to each service class of outputs, and there is no economically meaningful way to perform this allocation. Being able to derive separate output growth rates for interstate and non-interstate output categories is simply insufficient. Norsworthy's argument in the middle paragraph of p. 24 is disingenuous.

> The USTA model, while using these same three categories of interstate activity (end-user charges, interstate access, and special access), does not separately report an output aggregate for interstate access. Instead, its overall company output index contains these output measures embedded. The USTA assertion that there is no basis for measuring interstate activity separately is therefore belied by its own model.[27]

Quite the contrary. Since (a) the allocation of costs to interstate and non-interstate activity is not only impossible but, according to economic theory, meaningless, (b) even Norsworthy's attempt to adopt equal input growth rates is based on untenable assumptions (ones that even his own data

---

[27] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 24.

contradict), and (c) using his own data leads to inferences that contradict Norsworthy's conclusions, there is still no reasonable procedure by which to base an 'X' factor on pure interstate TFP accounting. The only economically meaningful course is to evaluate LEC TFP growth on a company-level basis.

(It should also be noted that adopting a total company-level analysis eliminates the need for the Commission to arbitrate the merit of any "separations adjustment" as proposed by Norsworthy. On the basis of cost transfers, Norsworthy imputes an additional 0.91 percentage point increase in his interstate 'X' factor.[28] Clearly, TFP must be evaluated on the basis of true input use--not on the basis of financial bookkeeping transfers addressing some historical rate-setting agreements that unarguably did not reflect true input use. That Norsworthy attempts to adjust for historical transfers only underscores the difficulty of performing separate interstate v. non-interstate analyses. A total company-level model has no need for an ad hoc separations adjustment.)

D. Issue 1b: Measuring the Cost of Capital

The USTA/Christensen model of the rental price of capital and the AT&T/Norsworthy Performance-Based model differ in a number of ways, but none is more important and revealing than their differing conceptual treatments of the rate of return to be used in calculating the LECs' cost of capital.

> The fundamental difference between the USTA assumed rate of return model and the Performance-Based Model can be illustrated by examining the revenues and costs of the firm. The USTA model of total factor productivity does not allocate all of the revenues of the LECs to inputs....On the other hand, the Performance-Based Model computes the rate of return by allocating all revenues received by the LECs to some category of input.[29]

---

[28] Ibid., pp. 29-30.

[29] Ibid., p. 31.

The rate of return in the USTA/Christensen rental price of capital formula is modeled by the LECs' ex ante opportunity cost of capital. In the AT&T rental price formula, the rate of return is modeled by the LECs' ex post or realized rate of return.

Economic theory makes clear that the rate of return measure in the rental price of capital formula should reflect external opportunity costs to the firm.[30] Economic costs certainly include the opportunity cost of capital but with equal certainty exclude realized economic profits above those opportunity costs. Norsworthy acknowledges as much in the draft chapter of a book he is co-authoring with Diana Tsai and appended as Attachment 2 of his Appendix A to the AT&T filing:

> In order for (9) (the cost of capital formula) and successive equations to make economic sense, the rate of return in (9) must be an expected *ex ante* rate of return based on the external cost of funds. Only in equilibrium will this rate of return be equal to the realized *ex post* rate of return...If investment in the enterprise is to be maintained, the expected or ex ante rate of return must be sufficient to offset the alternative cost of funds plus a risk premium suitable to the industry. The *ex post* rate of return must be sufficient on average to sustain the expectation of a sufficient *ex ante* rate of return.[31]

Note, as Norsworthy correctly says in this draft chapter, only in the context of competitive equilibrium will the realized ex post and ex ante rates of returns be equal. Otherwise, as Norsworthy states in the last sentence of the above quote, the only role for the realized rate of return is as a yardstick by which the firm determines whether or not it is earning its opportunity costs. Clearly, unless one is willing to assume perfectly competitive markets, ex ante and ex post rates of return may not be equal and, again citing Norsworthy,

---

[30] Most economic textbooks make this point explicitly. Two references are (i) Samuelson, Paul A. Economics. New York: McGraw-Hill, 1992. pp. 447-49 and (ii) Mansfield, Edwin. Economics. New York: W.W. Norton & Co., 1983. p. 736.

[31] Statement of John R. Norsworthy, Attachment 2 to Appendix A to AT&T filing, p. 4.

"the rate of return must be an expected ex ante rate of return based on the external cost of funds."[32]

ETI appears to be in full agreement: "From an economics standpoint, and consistent with the theory of efficient capital markets, the cost of capital or rate of return used in the rental price formula should be the expected or ex ante rate of return (alternative cost of funds plus a risk premium suitable to the industry) sufficient to attract capital to the industry."[33]

The problem is that the AT&T/Norsworthy model violates not only long-held economic principles but Norsworthy's very own draft chapter from his upcoming book. At no point in his draft chapter does he posit that (short of assuming competitive equilibrium) the realized rate of return is the appropriate measure of the ex ante rate of return, the opportunity cost of capital.

In truth, a firm's rate of return may be above (profit) or below (loss) its opportunity cost of capital. The Christensen/USTA model explicitly recognizes this real-world phenomenon. In fact, if the Commission were to adopt Norsworthy's model (the AT&T model), it explicitly would be adopting a cost-of-capital framework that necessarily implies that each firm is earning exactly its true opportunity cost of capital, thereby eliminating any need for regulation. In addition, the Norsworthy model is absolutely inconsistent with any price-cap model based on incentives that result from the LECs' ability to earn profits. To adopt a TFP framework that assumes each LEC is recovering only its opportunity cost of capital and therefore earning zero economic profits is not only wrong but absolutely counterintuitive.

---

[32] Ibid.

[33] ETI Statement, pp. 18-19.

The following text from Norsworthy's statement is particularly revealing (text that, in the original, is presented in boldface type):

> Why should total revenues exactly equal the total costs assigned to the inputs? There are two reasons: in principle, the economic theory of production requires it, and in practice, the regulatory authorities mandate it. The residual in Table 8 is just as much a cost to the ratepayers as is the total compensation of labor and the materials expense.[34]

First, though the economics profession is appropriately teased for its lack of agreement on many fronts, it is doubtful that Norsworthy could identify a single economics textbook that asserts that the economic theory of production requires that "total revenues exactly equal the total costs assigned to the inputs." The economic theory of production imposes absolutely no requirement on the structure of demand or revenue. A firm's technology and structure of input prices wholly determine its supply side. Any technology may map into either monopoly or perfect competition. Revenues equaling costs and profits equaling zero are not conditions required by the economic theory of production.

Second, Norsworthy states that regulatory authorities mandate that revenues equal costs. That may well have been the goal under the rate-of-return paradigm but it could not be further from the truth under <u>any</u> form of incentive regulation.

Third, Norsworthy's discussion of the residual (profits) as a cost to ratepayers states explicitly that the relevant basis for cost in a TFP model is payments made by consumers. No article in the productivity literature, or in economics for that matter, supports this position. This is a new brand of economics which totally eliminates the distinction between revenues and costs. Productivity measurement properly is tied to costs incurred by the firm.

---

[34] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 37.

Not only is Norsworthy and, therefore, the AT&T Performance-Based Model misapplying economic theory, but Norsworthy's concerns that using ex ante rates of return somehow will distort LEC incentives are simply misplaced.

> Because the USTA model does not account for this residual (excess returns) in capital input in its calculation of TFP--the only point where the cost of capital enters the PCI formula-- there is no incentive under its approach to price cap regulation for the LECs to adjust the quantity of capital to the overall cost-minimizing level. In other words, whatever level of capital a LEC chooses to put in place is **guaranteed a normal rate of return, just as under rate of return regulation**.[35] (Emphasis in original.)

The only kind of strategic behavior the Commission should be concerned about is whether a LEC believes its actions will affect its 'X' factor. As long as the process determining the 'X' factor is set in some presumably permanent fashion and the level of 'X' cannot be affected by a LEC's behavior, then the LEC has every incentive to invest in the efficient level of capital and all productivity enhancements. Norsworthy seems to misunderstand the role of the TFP calculation. It is being used only to set the proper 'X'. Once it is set, however, and assuming it will not be adjusted by a LEC's actions, the LEC has an unambiguous incentive to maximize its productivity growth.

The statement that price-cap regulation (under either an ex ante or ex post rate of return) guarantees a normal rate of return to any and all levels of capital investment is simply wrong. If any cost-of-capital specification guarantees the LECs a normal return, it is the AT&T model which assumes that realized returns (including all profits and losses) should be used to measure the LECs' ex ante opportunity cost of capital.

---

[35] Ibid., p. 38. It is also important to note that Norsworthy is simply wrong when he asserts that the only point at which the cost of capital enters the PCI formula is through the 'X' factor. In 1990, LEC price cap rates were targeted to produce an 11.25% rate of return, the Commission's then current estimate of the cost of capital. The price-cap indexes were initialized based on these rates.

Norsworthy continues with the argument that failing to apply realized rates of return leads to a biased measure of TFP growth and therefore 'X' because it "results in understating the total factor input and in understating the growth in total factor input when capital growth is positive."[36] If Norsworthy were correct, the policy implication is that the Christensen/ USTA model leads to higher measured TFP growth and therefore a higher 'X' factor. "Correspondingly, TFP and the growth in TFP--the 'X' factor--are overstated....Use of the correct weight would lead to a lower measured performance: lower TFP and a lower X-Factor."[37] This is clearly an unusual position for AT&T to take.

The most confusing part of Norsworthy's argument supporting the use of the realized rate of return as the LECs' measured cost of capital is the premise (last sentence of p. 41) that each LEC's 'X' factor at the "end of the current period" is adjusted based on the LEC's own measured performance.[38] First of all, the case critiquing LEC-specific 'X' factors based on each LEC's actual performance should be clear to all. Second, whether profits are or are not allocated to capital will lead to the same strategic behavior problem if each LEC's 'X' factor is adjusted "at the end of the current period" based on its performance in the prior period. Whether or not to assign profits to capital should be determined on the basis of economic theory and that theory is clear. The opportunity cost of capital is a cost. There is no requirement that profits equal zero--either in the realm of economic theory, the real world, or under any price-cap paradigm.

The AT&T Performance-Based Model should simply be rejected. It incorrectly applies the economic theory underlying the cost of capital, it

---

36 Ibid., p. 41.
37 Ibid.
38 Ibid.

misrepresents the economic theory of production, it bases its model on a rate-of-return paradigm, and, most tellingly, it assumes away the need for any form of regulation. It posits that each LEC's realized ex post rate of return equals its opportunity cost of capital. If so, the case for regulation disappears.

E. Issue 1a: Proper Weights for Output

Norsworthy addresses the conceptual desirability of using marginal cost weights in the computation of aggregate output. The problem with marginal cost weights is not one of principles but of practice. Norsworthy himself recognizes the sensitivity of econometric measures of marginal cost: "The difficulty is that the econometric procedures required to estimate marginal cost weights may give results that change with small changes in the data or in the way that the model is specified. Statistically, results that are sensitive in this way are not robust."[39]

Though marginal costs estimates would not be statistically robust, Norsworthy criticizes the USTA/Christensen model because it weights output growth rates with revenue shares. (Note, ETI adopts revenue shares as output weights.[40]) Norsworthy recommends using revenue requirements because they "represent the long-term marginal costs of the respective services and are thus superior to revenues as a basis for aggregation."[41]

Equating revenue requirements with long run marginal costs not only requires solving age-old cost-allocation problems already discussed but also effectively assumes constant returns to scale. This follows because only under constant returns to scale are fully allocated or average costs (revenue requirements) equal to marginal costs. Constant returns may not be an

---

[39] Ibid.

[40] ETI Statement, p. 18.

[41] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 23.

unreasonable assumption, but it contradicts the economies of scale premise underlying Norsworthy's analysis of distinct measures of interstate and non-interstate TFP growth. More importantly, in the above discussion of the cost of capital, Norsworthy argues that the AT&T Performance-Based Model imposes the condition that total revenue equals total costs. Putting all this together leads to the following description of the economic model proposed by Norsworthy. Under constant returns to scale (assumed by Norsworthy), marginal cost equals average cost. Under total revenue equals total cost (assumed by Norsworthy), one gets price equals average cost. Therefore, price equals marginal cost. In short, the assumptions underlying Norsworthy's model justify using either revenue or revenue requirement weights. The former are price based; the latter are marginal-cost based. For Norsworthy, they are equivalent. More generally, given its restrictive nature, Norsworthy's model is conceptually consistent with any set of output weights, whether based on revenue, fully-allocated cost, or marginal cost.

It is also important to emphasize that Norsworthy's suggestion that the FCC adopt a model based on revenue requirements requires that the Commission maintain cost-allocation rules so familiar to traditional rate-of-return analysis. Measured revenue requirements are wholly inimical to the price-cap paradigm.

F. Issue 1a: Fisher Ideal v. Tornquist Indexes

The principal advantage cited by Norsworthy of the Fisher Ideal index over the USTA/Christensen Tornquist index is that the Fisher Index better "accommodates the introduction or disappearance of services...covered by the index."[42] Since any variant of a TFP index adopted by the Commission will

---

[42] Statement of John R. Norsworthy, Appendix B to AT&T filing, p. 5.

deal with significantly aggregated components of interstate, intrastate and local service and labor, capital, and material inputs, this advantage of the Fisher index will never be realized. There is little risk that any one of the aggregated output or input categories will move to zero and that this advantage of the Fisher index will ever be operative. This conclusion is validated by fact that Fisher and Tornquist indexes applied to LEC data yield identical series of output, input, and TFP growth rates.[43]

It is also important to note that the Bureau of Labor Statistics currently uses a Tornquist-based formula to calculate TFP growth for the U.S. economy and its major sectors. For its comparative purposes, the Commission seems well advised to adopt a TFP specification that not only is soundly based in economic theory but also is the basis for government-produced TFP growth measures for the aggregate economy, the base against which any LEC TFP differential is to be calculated.

G. Issue 1a: Service Quality

Norsworthy opens his discussion of service quality by referencing results from his past research indicating that LECs increase their efficiency and/or profitability at the expense of service quality. He quickly acknowledges that his conclusion is based on empirical results for a period (1986-90) that preceded the initiation of price caps but then adds:

> If anything, the incentives are stronger now for the LECs to reduce service quality in exchange for profitability. The notion that competition will regulate service quality applies only when there is *actual* competition. The contemplation of future competition in the LECs' markets does not in itself diminish the incentive to reduce the quality of service.[44]

---

[43] Christensen Reply Comment under CC Docket 94-1, dated March 1, 1996, p. 8.

[44] Statement of John R. Norsworthy, Appendix A to AT&T filing, p. 63.

At best, Norsworthy's statement applies to an absolute monopolist protected by insurmountable barriers to entry. In this instance, potential entrants are either nonexistent or cannot be expected to affect the monopolist's behavior. These conditions, however, describe neither the LECs' environment in 1996 nor the expected state of competition in the immediate future. The actual and potential competition unleashed by the Telecommunications Act of 1996 makes it absolutely irrational (i.e. unprofitable) for LECs to decrease their service quality. Doing so would (a) encourage entry and (b) disaffect customers, making them more likely to switch to competitors. There is absolutely no economic basis for Norsworthy's conclusion.

Moreover, his conclusion appears to be contradicted by his own research. On the very page following the above statement, Norsworthy states:

> There are ten quality variables taken from the Automated Reporting Management Information System (ARMIS) that I have examined. All are increasing through time and average near .90. The reported data cover the period from 1986 to 1990...[45]

Every one of the 10 dimensions of service quality Norsworthy hand-picked increased over the very period he analyzed. There is neither a basis in economic theory nor a foundation in empirical reality for Norsworthy's claim that the LECs have sacrificed service quality to enhance either efficiency or profitability.

Norsworthy attempts to support his position through reference to regressions that, in four of ten cases, generated the alleged negative relationship between efficiency and service quality. (Though he reports that overall service quality has improved in every one of his ten dimensions, he uses four of ten regressions to infer a negative relationship between efficiency

---

[45] Ibid., pp. 64-5.

improvements and service quality.) He does not define his regression models with any specificity but makes the following revealing comment:

> These various quality measures (the ten referenced above) were regressed on several sets of variables representing technology, i.e., the distribution of working channels among baseband, analog, digital and fiber types and the proportion of fiber interoffice cable miles. While improved switching and transmission equipment should improve several dimensions of service quality while reducing telephone company costs, more refined empirical analyses and a larger data set would be required to investigate these relationships more completely.[46]

This last sentence suggests that Norsworthy's models ignore, among other things, improvements in switching and transmission equipment, yet at least 7 of the 10 quality variables he selects for analysis would be expected to be highly and positively affected by such improvements: satisfaction of residential customers, satisfaction of large business customers, satisfaction of small business customers, percent of interLATA connections completed, percent of intraLATA connections completed, dial tone response time, and transmission quality.[47] There is little doubt that Norsworthy's ten regression models suffer from specification bias.

His empirical results illustrate the effect of this bias. If Norsworthy had included improvements in switching and transmission equipment in his models (especially in the seven models listed above), he would likely have found positive relationships between efficiency and service quality. After all, Norsworthy himself states: "improved switching and transmission equipment should improve several dimensions of service quality while reducing telephone company costs..."[48] What does Norsworthy find? In regressions for 6 of the 7 models most biased by the exclusion of equipment

---

[46] Ibid., p. 65.
[47] Ibid., p. 66.
[48] Ibid., p. 65.